Personalised Live Sports Event Viewing on Mobile Devices

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Abstract— A personalised mobile sports event viewing system that enables users to efficiently and naturally direct movies of their own live sports events on mobile devices is described. Personalisation here focuses on the selection of live events with respect to multiple sports disciplines. An implicit user model driven approach is used to enable the system to adaptively predict users' preferred events during live sports shows. The design of this personalisation model, developed as part of the My-e-Director 2012 project, is described and an associated mobile prototype system is presented.

Keywords- Personalisation, sports event viewing system, mobile application, metadata, user profile.

I. INTRODUCTION

Viewing videos on mobile devices is increasingly popular amongst mobile users, driven by the increasing availability of wireless networks and wider ranging mobile hardware. These promise more innovative live viewing services on mobile devices. The implications for mobile service access are multi-fold. First, viewers have more flexibility to select which channels, i.e., sports events, they prefer to view. This is particularly an issue for large scale live sports events such as the Olympics that consist of a larger set of concurrent events. Second, access to more pervasive mobile services requires newer kinds of user device interaction [7]. Support for sensor based interaction, coupled with mobile device resource limitations such as screen size limitations and the increasing number of live event items, i.e., information overload, contribute to changes in users' operational efforts, i.e. browsing actions, and the efficiency to finish a specific user task.

To reduce users' operational efforts while increasing users' task efficiency, a personalised viewing system is required. This tailors services to better fit user preferences. This approach may hinder users' control over systems [3] when the adaptation is done implicitly. The adaptation occurs at two levels. First, the system chooses the events for users. Second, users select events from a reordered event list from the system. The former allows the system to automatically perform the adaptation without users browsing the event list and the latter maintains user control of the sports event selection while the system adaptation is active.

In the paper, the issue of personalisation is addressed at two levels: The first regards the adaptation of the transmitted content for the personalised sports event viewing preferences and the profile of the user, while the second deals with the personalisation of the user viewing experience. The latter can be provided through the customisation of the user interface on a personalised terminal device.

The remained of the paper is organised as follows. Next, a review of related work is presented. Then an introduction of sports event selection personalisation model follows. The implementation of the model in the prototype system is presented, and some validation results are shown and finally the future work are discussed.

II. RELATED WORK

Several research papers concern sports event, mobile services and mobile user interfaces respectively, such as [9] [4] [8]. These are grouped into two categories in terms of their study focus, namely mobile user interface centric and in terms of sports event user preference centric.

A. Mobile User Interface

A considerable amount of mobile user interface work is concerned with studying the interaction between users and devices. In [1], an intelligent user interface is introduced which integrates adaptive navigation techniques into a widget engine. The adaptation here is more relevant to the customisability of the user interface. In [4], pen-based video navigation mobile user interfaces are presented with no consideration for adaptation. Although these articles demonstrate a different means to perform and enrich the user-mobile interaction, their objectives are the same, that is, to allow users to have more control of the system.

In this paper, the focus is on the design of the user interface so that it not only provides an increased and richer

control but also supports the system's adaptation to user preferences for sports events.

B. *Sports Event User Preferences*

Sports event user preferences refer to the system's interpretation of individual user's preferences of sports event with respect to multi-faceted properties such as event type, event venue and athlete's performance. In [10] and [13], a score voting system is used to allow users to express their own judgements concerning athletes' performance. In [16], users are explicitly asked to express preferences for pre-prepared video segments. [8] uses attention analysis to model users including directors, the audience and commentators, and to detect the event highlights. These approaches all require an explicit user input such as questionnaires and voting in order to construct a user model. Most of these also tend to focus on one particular sports event, e.g. football is mostly used.

Explicit approaches such as popup questionnaires and voting could possibly interrupt and undermine users' viewing experiences. More importantly, users' preferences may not be updated in a timely fashion unless the system continuously prompts users or allows them to spontaneously volunteer amendments. Hence, an implicit approach is used to obtain user preferences for a set of explicit events.

III. PERSONALISATION SERVICE MODEL

A. *Overview*

Personalised event selection ranks a list of live events in accordance with user preferences of event types. The service uses the following procedures. Users initially select events in order to trigger the system to start the creation of a user model. The system later uses this information to determine users' preferences and to predict these later in a session, or in future user sessions. A user's model is maintained in the form of a user profile which defines users' observed viewing durations for particular sports events for each user session and defines user event preferences in terms of sports event type definitions. Figure 1 shows the system framework for the personalised service model.

The beginning of each viewing session is defined as the activation of the "play" button on the mobile device user interface. Before each viewing session, the system collects both live sports event information and accesses user profiles for previous viewing sessions. Both inputs are processed by the sports event user preference module. The results are reordered in an event list that ranks sports event types by preference, from the most to the least preferred. At the end of each viewing session, the user profile is updated, and the latest user preferences are determined with respect to the sports event definition.

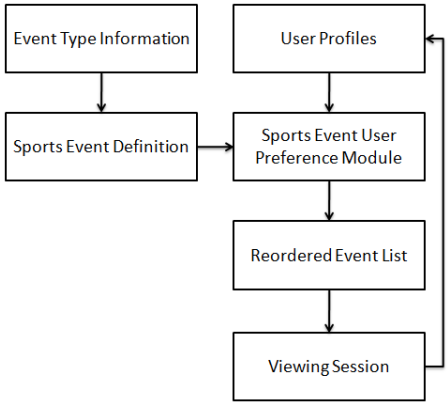

Figure 1 Personalised Event Selection Model

B. *Sports Event Definition*

There are around 26 summer sports and 8 winter sports disciplines according to the International Olympic Committee [11]. These sports vary according to multidimensional properties. These properties can be their play strategies (invasive, defensive, etc.), achievable targets (gate, distance, etc.), equipment and so forth [2]. Some of these properties are vague. For instance, the football game can be thought of as either an invasive or defensive game. In addition, there may be definition overlaps among these properties, e.g. football could be a ball game in terms of physical equipment but also as a field game and in terms of the venue of the game. In order to avoid the vagueness of such properties, sports events in this work are defined in terms of properties associated with international game rules.

A sports event is normally shaped by a set of common game rules. These rules are expressed as different quantitative properties. The variations of property values can discriminate one sports event from another. Here, such properties are defined as explicit event metadata.

With reference to the official website of the International Olympic Committee [11], the following user interests associated with explicit event metadata are defined:

a) Competition field area – user interests follow how successful the competitors they initially support are.

b) Number of participants per game per session – users' interests follow team or individual events and their competition intensity.

c) Number of in-game sessions – users' interests follow the game uncertainty due to session transitions.

d) Required game equipment – users' interests for viewing the game outcome can change with respect to equipment movement, direction and performance uncertainty.

e) Minimum number of competition direction changes – users' interests for event results are uncertain due to direction transitions.

f) Number of standard event actions – users' interests on athlete skills, incidents and kinematical aesthetics.

Table 1 shows an example for defining a football event. A summary of seven properties in terms of event metadata are defined in Table 2. Standard metadata instances are determined with reference to [5] and [11].

Football	
Competition field area	110 x 75= 8250
Number of participants	22 players
Number of in-game sessions	2 sessions
Minimum number of competition direction changes	1 ball
Minimum number of competition direction changes	1 time direction change
Number of standard event actions	Hand ball; offside; Foul; Charge; Corner Kick; Direct free kick; Dive; Dribble; Free kick; Goal; Goal kick; Indirect free kick; Kick-off; Own goal; Penalty kick; Penalty shoot-out; Penalty spot; Yellow/Red card; Save; Tackle; Take a dive; Throw-in (22 in total)

Table 1 Football Definition

Event	Vector Description
#0 Football	{8250, 22,2,1,1, 22}
#1 Basketball	{420, 10, 4, 1, 3, 24}
#2 100 meters race	{117, 8, 1, 0, 0, 2}
#3 400 meters swimming	{1000, 8, 1,0, 7, 7}
#4 5000 meters race	{46800, 15, 1, 0, 0, 1}
#5 Beach Volleyball	{128, 4, 3, 1, 7, 10}
#6 Long Jump	{58.5, 1, 3, 0, 0, 1}

Table 2 Concerned events definition in vector forms

C. User Profile

Profiles represent markup-scheme models such as the Capabilities/Preference Profile (CC/PP) [14] and the User Agent Profile (UAProf) [15]. User profiles here represent a simple model that reflects users' viewing preferences during viewing sessions. In our mobile application, user driven parameters are implicitly dictated, encoded and stored on users' mobile devices. The process is viewing session driven, i.e. each record item is linked to a particular session.

Two crucial user operational driven parameters are dictated by the system, one is the event type viewed and the other is the duration of the viewing session. The viewed event type represents the user preference for the sports event type at that moment and the relative viewing duration indicates the relative duration of a user's preference, i.e. the actual live event total duration of the event divided by the actual viewing duration by a user. The viewing duration excludes the video player buffering time. This data is encoded in XML based structure as:

<session date = "04/05/2009 21:27:36", event = "Football", duration = "0.23" />…<session …. />

The stored user profiles for user past operations can be retrieved once the sports event user preference executes.

D. Sports Event User Preference Module

The module inputs both the live event list and user profiles and it outputs a reordered event list. The module consists of the steps defined as follows. At the beginning of viewing session T:

a) Calculate user preferences with respect to the defined event metadata by using the stored user profiles for viewing sessions from T-1 to 0.

b) Compare the latest accumulated user preferences for live sports events from a viewing session T-1 to T-t with respect to the live sports event list for this viewing session, where t is a threshold value that is used to adapt to the user preference orientation change, e.g. events in final rounds could be more attractive, whilst neglecting past sessions.

After the viewing session T:

c) Update a user profile in terms of the viewed event type and relative viewing duration

As the sports event defined by the event metadata can be expressed in a six dimensional vector, it facilitates the system to do comparisons among different events. For example, using two relative irrelevant events, football and swimming, differences between them can still be told by obtaining a similarity value between the two events.

Given the event vectors

Ea: $(E_A = (E_AM1, E_AM2,\ E_AM3,\ E_AM4, E_AM5, E_AM6))$ and event

Eb: $(\ E_B = (E_BM1, E_BM2,\ E_BM3,\ E_BM4,\ E_BM5, E_BM6)\ )$ and the angles between the two, their vectors can be expressed using the following formula.

$$\alpha = arccos(\frac{< vE_A|vE_B >}{||vE_A||\ ||vE_B||}) \quad (1)$$

The smaller the angles are, the more similar any two sports events are.

Due to the fact that all the event metadata instances can be perceived by users as visual elements, the sports events user's preferences can also be expressed with respect to the event metadata. As a result, user A can be described as

$U_A = (U_AM1, U_AM2,\ U_AM3,\ U_AM4, U_AM5, U_AM6)$). U_AM1 is known as user A's preference of its first metadata type, e.g., the competition field area. Users' preference for metadata instances are accumulated by a predefined number of viewing sessions. The following formula explicitly represents user preferences over sports event temporally.

$$U_A{:}\left(U_A\frac{\sum_i^n M1*P_i}{n-i}, U_A\frac{\sum_i^n M2*P_i}{n-i}, \dots, U_A\frac{\sum_i^n M6*P_i}{n-i}\right), \quad where\ P_i = \frac{t_i}{T} \quad (2)$$

i denotes the ith viewing session which starts with a new list of live events, n denotes the nth viewing session, each viewing session represents a switch of event viewing so that the difference of $n - i$ would be the number of viewing sessions that are predefined. P_i denotes the percentage of ith viewing session in the total relative viewing duration, i.e.

the session duration t_i divided by total relative viewing duration T.

It should be noted that the values of a computed user preference vector may differ with respect to the defined sports event vectors unless the user keeps viewing one particular preferred event. Therefore, at the beginning of a new viewing session, the latest user preferences can be compared with the provided sports event by using formula (1). The comparison results produce a ranked event list, i.e. from a user's most preferred to least preferred events. The system afterward could automatically present users with their top ranked events as explained in the next section.

IV. MOBILE DEVICE USER INTERFACE

There are a few mobile interfaces specially designed for live video streaming. Existing mobile user interfaces (UI) for media players are mostly designed to playing local media files with less focus on the system adaptation. The design of the UI focuses on effective and efficient access to live streams on the mobile terminal. The mobile UI presented in this paper is developed with the .NET compact framework (.NET CF) and runs on a Microsoft Windows mobile compatible operating system. The UI is divided into two parts. The first part is the navigational UI that allows users to select their preferred live streams. The second part is the viewing screen UI that allows users to control various aspects of the live stream such as volume, and screen size.

A. Navigational User Interface

Traditionally some windows mobile applications used a desktop metaphor to construct their UIs. However such a design is often not suitable for mobile applications [7]. For example, it is often annoying to place menu options in a tiny menu bar, this is especially inconvenient for one handed operation. In addition, small screens can make it easier for UIs to violate interaction design principles such as overloading users' conscious memory [6]. To address these issues, a mobile UI developed in this work is designed to support one handed operation and to use a cascade style workflow to complete certain user tasks.

A set of native code with respect to GDI+ (Graphic Device interface) and to default windows form UI controls of the .NET compact framework 2.0 can be overwritten to support a new set of UI controls that support touch interaction. Figure 2 illustrates the resulting navigational UIs.

B. Viewing Screen User Interface

The main component of the viewing screen UI is the video player and control panel. We customised the windows mobile media player by adding extra controls such as hide/show player panels and streaming state indications. In addition, accelerometer sensors incorporated in current mobile devices such as smart phones enable users to switch between viewing screen and to navigational menus. Users just need to simply shake such a mobile device, using a certain hand gesture. The viewing screen is hidden from user until a user starts a new viewing session. Figure 3 demonstrates this UI.

Figure 2 Navigational UIs for Event Selection

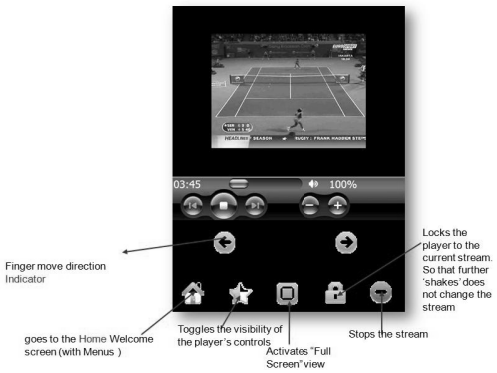

Figure 3 Viewing Screen UIs

V. IMPLEMENTATION AND SIMULATION

A. Service-UI Integration

The personalised event selection model has been integrated with a mobile UI and its associated user task model. The Concurrent Task Tree (CTT) notation [12] is used to model the user tasks defined in this paper as it is able to present the temporal relationships between these tasks.

The tree structure describes the composition of tasks such as the "view event", interactive task and system task. These are labelled differently. The relationship ">>" denotes an enabling relationship whereas "[]>>" denotes an enabling with information exchange relationship. In order to indicate the positions in which the personalisation services are applied, labels "S1" and "S2" are used as annotations, i.e. before the system displays the reordered list and after each viewing session.

Figure 4 shows an implementation of the personalisation service via the direct view mode. In this task the system adaptively applies personalisation to determine users' preferences for events based upon user profiles. Note that if there is no user profile record, the system would randomly choose am event type from the live event information list.

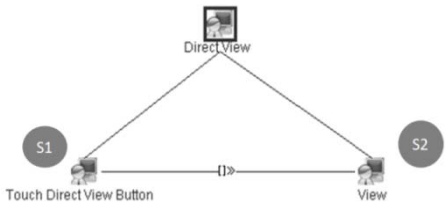

Figure 4 User Task- Direct View with CTT notations

Figure 5 shows an implementation of a personalisation service for two sequential user tasks, namely select event and view event. The implementation gives users full control of their sports event choice as users are allowed to flexibly choose any event in the reordered list, i.e. the first item in the list may not be chosen by the user.

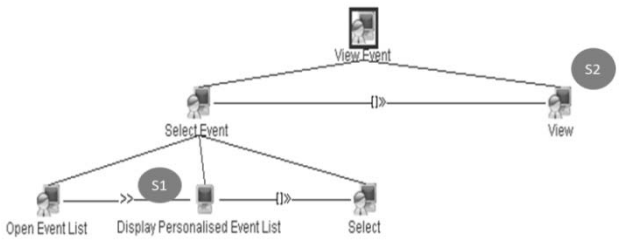

Figure 5 User Task- View Event with CTT notations

B. Simulation

In order to validate the personalisation service on a mobile device and to verify it works properly, simulation techniques were performed. The simulation for event selection has been performed on a Windows mobile emulator.

Simulation # (selected event.)	User Preference (according to the metadata coding presented earlier)	Live List (# event)	Personalised List
1 (5)	N/A	0-3-1-5-2-6	N/A
3 (3)	(593.76, 6.14, 1.93, 0.47,7,8.40)	3-5-6	3-6-5
9 (5)	(460.84, 4.68, 2.29, 0.08, 3.02, 5.28)	6-4-3-5	4-3-6-5
12 (6)	(177.44, 4.77, 2.67, 0.47, 3.22, 7.19)	6-3-4-5-2-0-1	4-0-3-6-2-1-5
15 (3)	(14066.23, 10.12, 2.19, 0.53, 2.82, 8.37)	1-4-5-2-6-3	4-3-6-2-1-5

Table 3 Selected personalized list simulation results

Live event list information is simulated by using an event generator which is able to generate a random number for event types ranging from 3 to 7, i.e. 3 to 7 events each time. A pseudo user is assumed to have particular interests for the #3, #5 and #6 events and to have equivalent interests on another event. Therefore, the user selection is simulated by randomly choosing the event from their personalised list with the priorities on that user's three preferred events. The user relative viewing duration is simulated by a random number ranging from 0 to 1. The latest five viewing sessions are taken into account as the accumulated user preferences. The simulation runs for 18 viewing sessions. Table 3 shows the personalised event list based upon the user profiles and live events list. The system adaptation capability is evaluated based upon the distance from the user chosen event position to the top of their personalised list. The distance is defined in terms of a cost function. Figure 6 demonstrates the simulation results of the personalisation service (which runs 18 simulation epochs). The service adaptively generates the personalised event list based upon user preferences and eventually reduces the average cost.

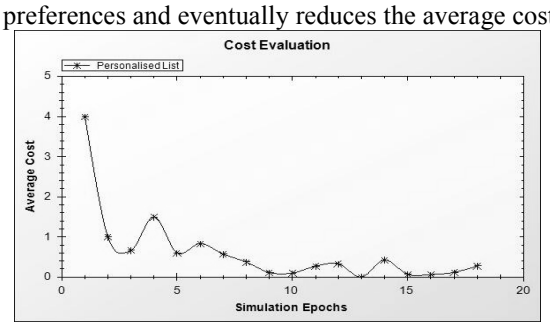

Figure 6 Adaptation evaluation

VI. CONCLUSION AND FUTURE WORK

In this paper, a personalised sports event service has been applied to a mobile live sports event viewing system. The resulting system is able to adaptively determine users' preferred event types based upon user profiles and past viewing information. The system allows users to have some control of the system, i.e. the system's actions are predictable, when adaptively performing the personalised event selection service. In this service invocation, sports events are defined with respect to various aspects that are commonly recognised, which cam reduce any semantic variability across heterogeneous systems. User preferences are interpreted in accordance with accepted sports definitions and expressed in multi-dimensional vectors which facilitate the discovery of users' preferred events. The simulation results demonstrate that the personalisation service works as expected and is able to reduce the cost effectively.

In the future, we plan to investigate different dimensionalities that could contribute to user preferences, such as the participants in the event and the weather during the event. In addition, user tests can be carried out to evaluate the system and to assess its adaptation capability and usability.

Finally, the issue of context awareness as regards the viewing conditions and the situation in which the viewer is located will be investigated. Hence, the personalisation of the viewing experience can take into account parameters such as environmental conditions. Context awareness is able to support advanced adaptation techniques beyond the traditional brightness and sound level adaptation, addressing a richer media viewing experience. Examples include the selection of the most appropriate camera, such as a close-up camera in situations for the case where a user is located in bright light conditions. A distant view would be pointless in

such conditions due to the inability to detect particular athletes. Furthermore, some adaptation according to the power level of the device could be applied by switching to audio and by turning off the video display when a low stored power capacity is sensed. Context adaptation could also involve the detection of the physical situation of the user, i.e. moving inside a car, and then adapting the user interface to these conditions such as shutting off the video and adapting the sound level.

ACKNOWLEDGMENT

This work has been undertaken within the framework of the My-e-Director 2012, Real-Time Context-Aware and Personalized Media Streaming Environments for Large Scale Broadcasting Applications, FP7 Project (grant No. 2152482012), funded by the European Community. The authors also thank other members of the project consortium for their support and guidance.

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